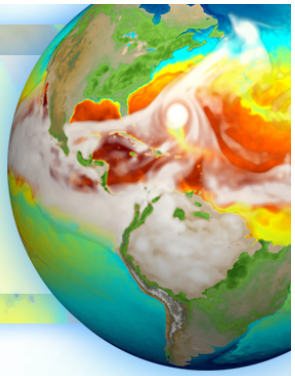


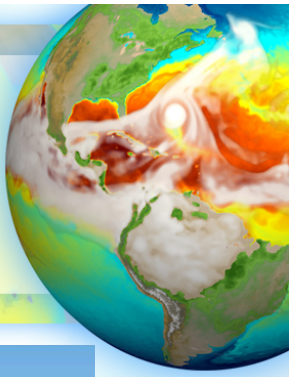
E3SM Next Generation Development (NGD): Land and Energy

Ben Bond-Lamberty

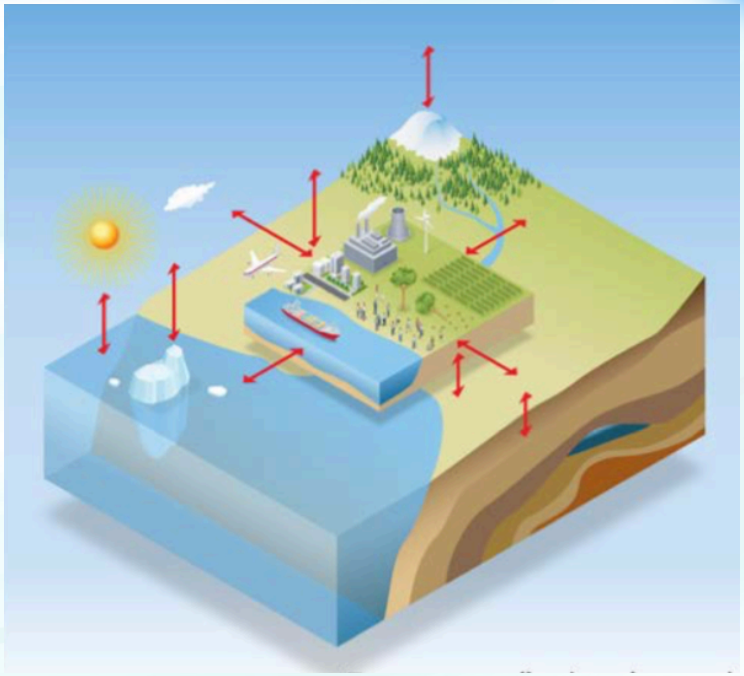
(on behalf of many)

E3SM All-Hands – October 26, 2020

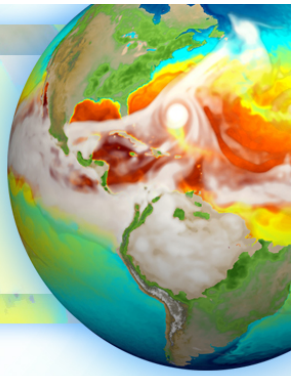
v3/v4 science questions



- **Water cycle**: How will the moisture sources and precipitation over land change?
- **Biogeochemistry**: What are the impacts of different energy and land use on land biogeochemistry and terrestrial-aquatic processes?
- **Cryosphere**: What are the implications of sea level rise and extreme storms for coastal inundation?

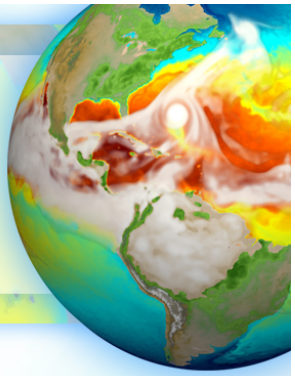


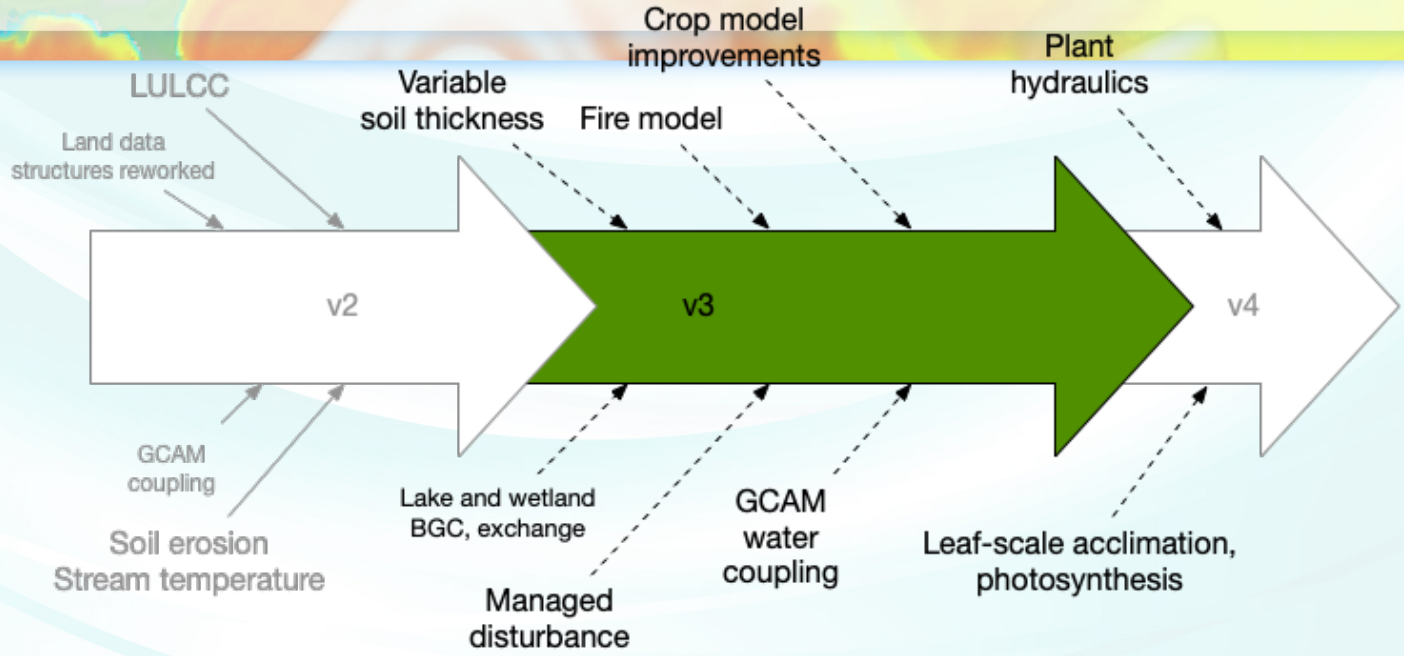
Model capability gaps



- For *water cycle* questions:
  - No subsurface lateral flow or influence of hydraulic traits on hydraulic mortality; these influence evapotranspiration
- For *biogeochemistry* questions:
  - Land use change and disturbance effects have known biases
  - Limited wetland/floodplain and no hyporheic zone
  - Limited interaction between vegetation dynamics and mortality
  - Known problems with photosynthesis/stomatal controls (again ET)
- For *cryosphere* questions:
  - Land-water interfaces not well modeled (above)

Land-Energy NGD overview





High-res NA GPU

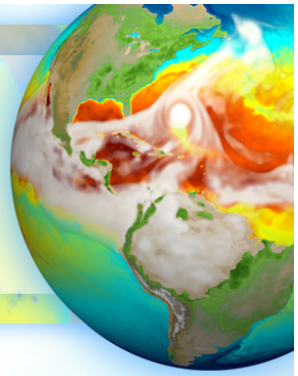
FATES

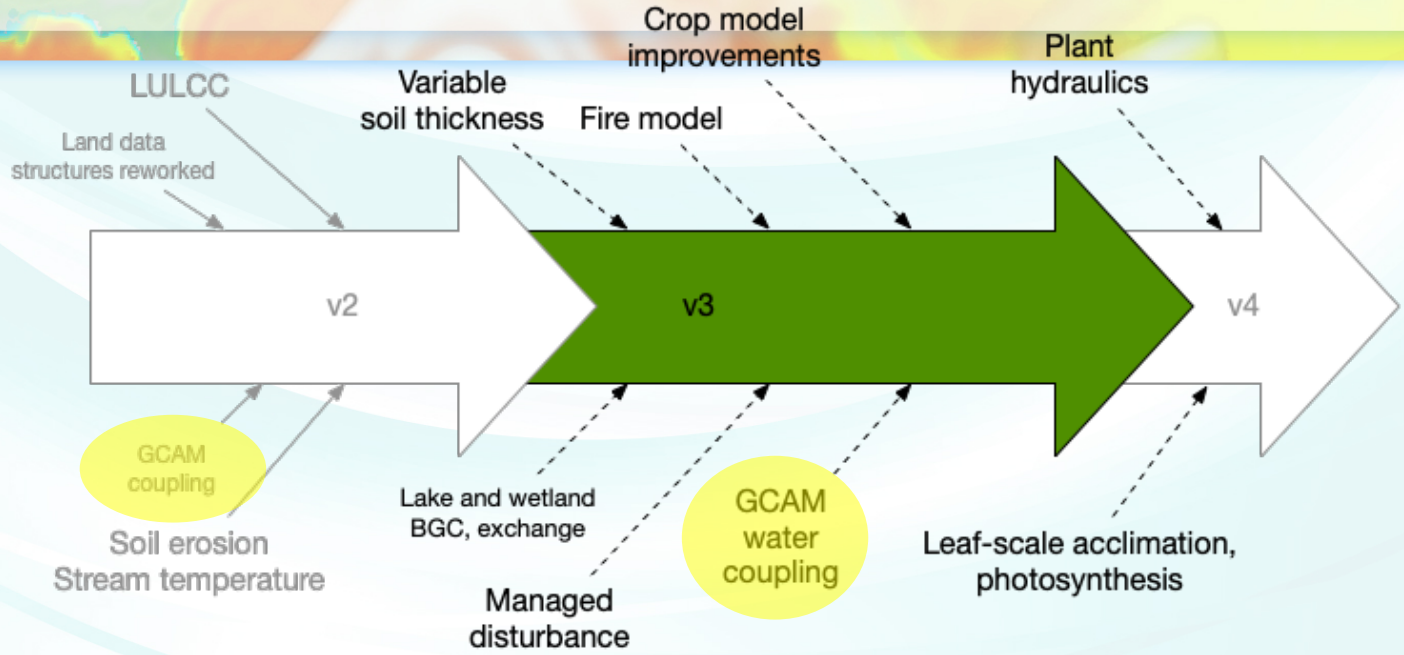
External model interface

E3SM Energy Exascale Earth System Model

U.S. DEPARTMENT OF ENERGY

Land-Energy NGD overview





High-res NA GPU

FATES

External model interface

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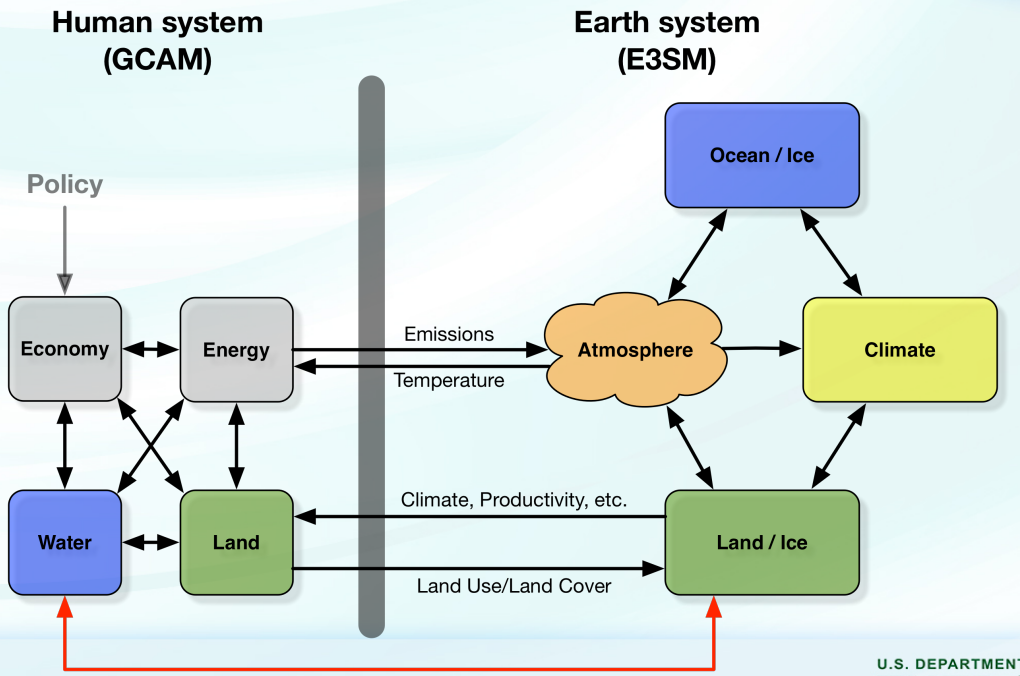
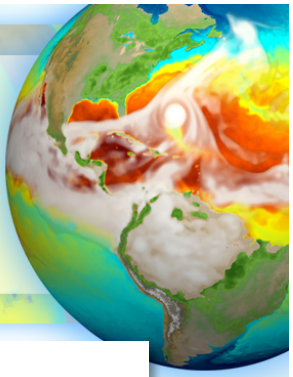
E3SM-GCAM coupling

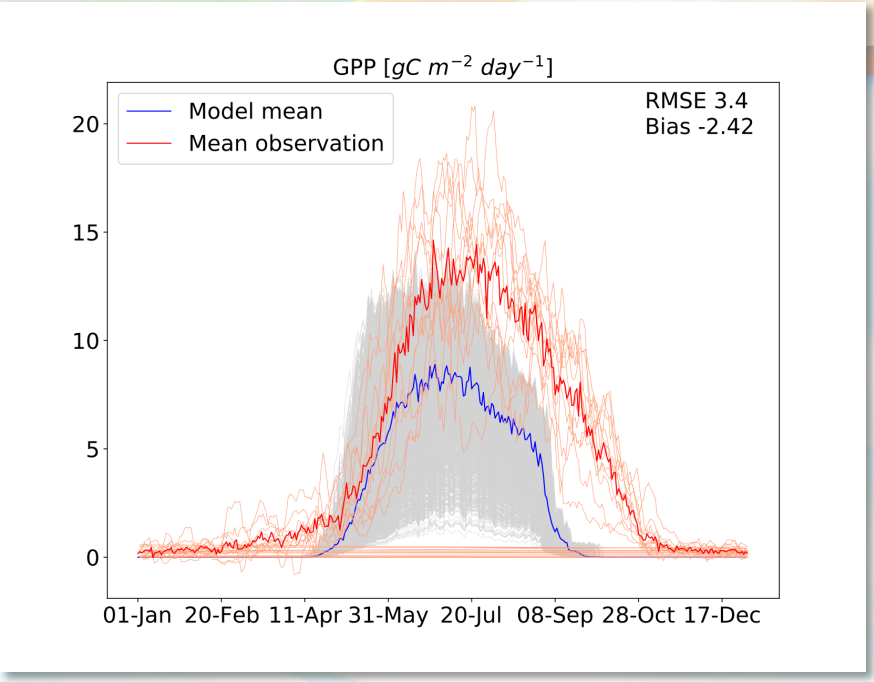
Land/energy
Water cycle
Biogeochemistry

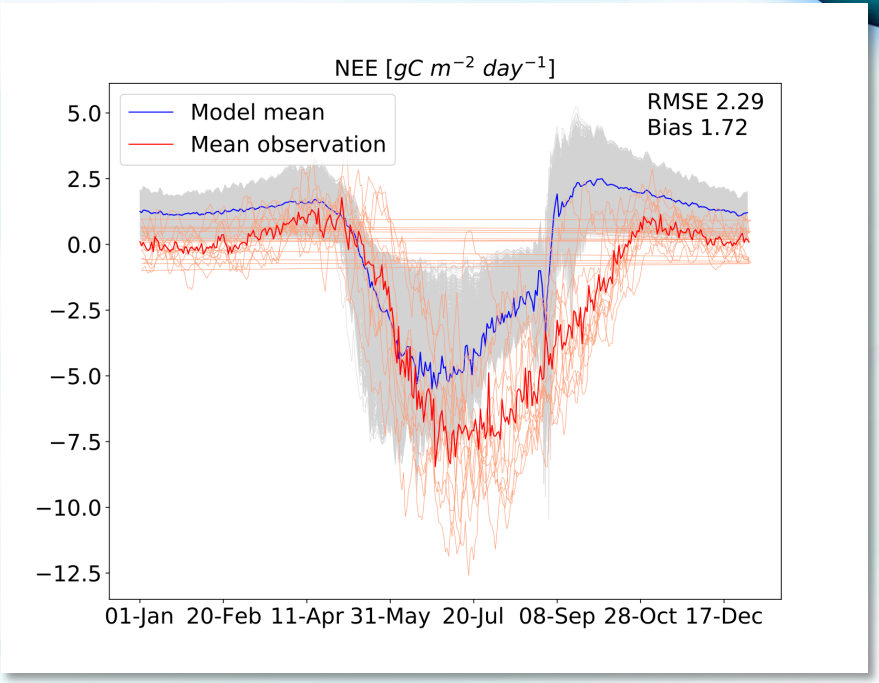
- v2 tasks finishing now
- For v3 will want to step back and re-think approach and tools (e.g. GLM)



Modeling Bioenergy Crops in ELM

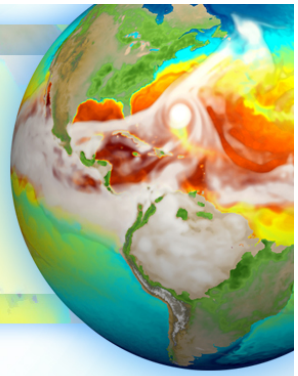


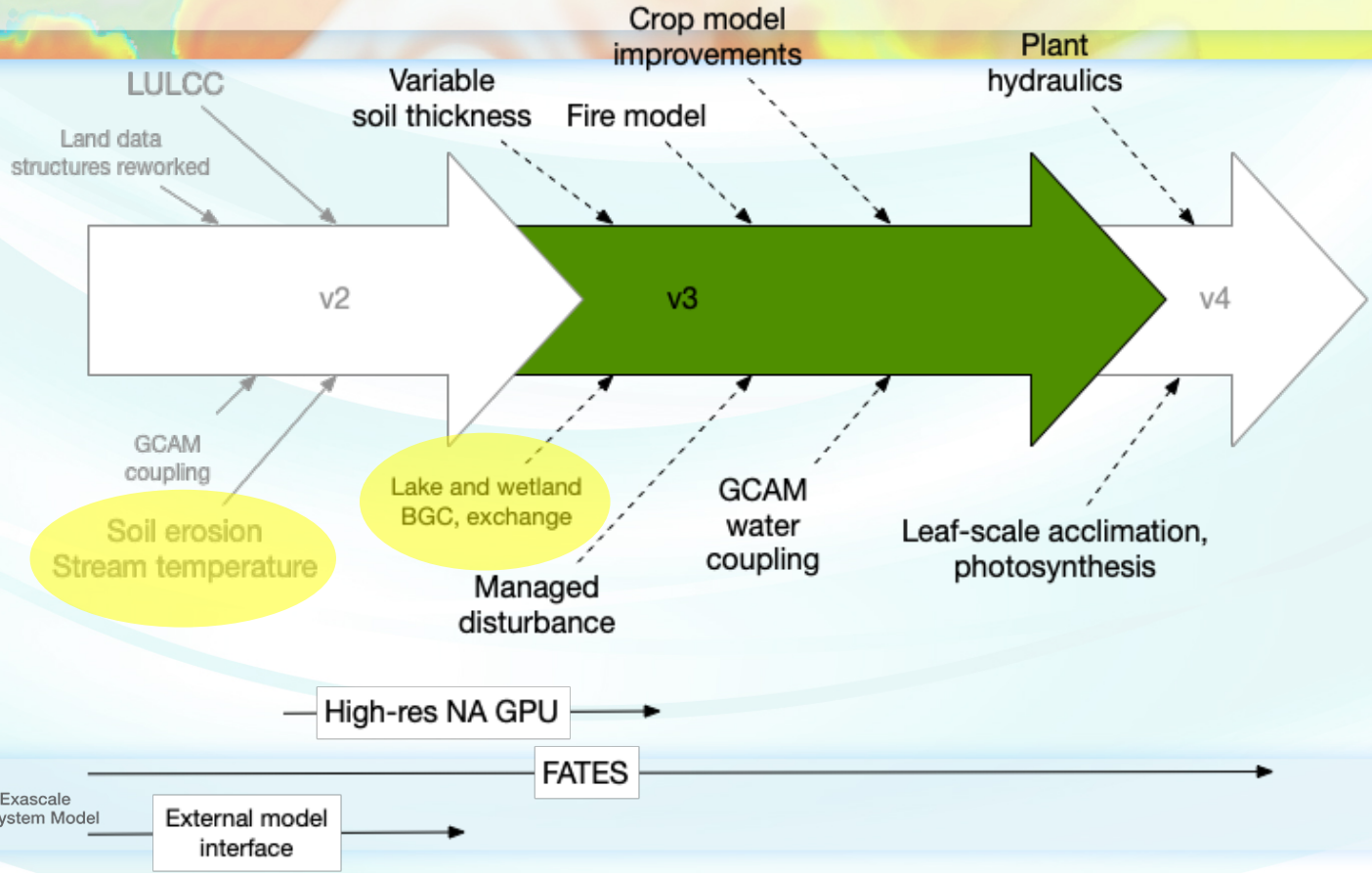




See Eva Sinha's poster on Tuesday (PS1)

Land-Energy NGD overview





E3SM Energy Exascale Earth System Model

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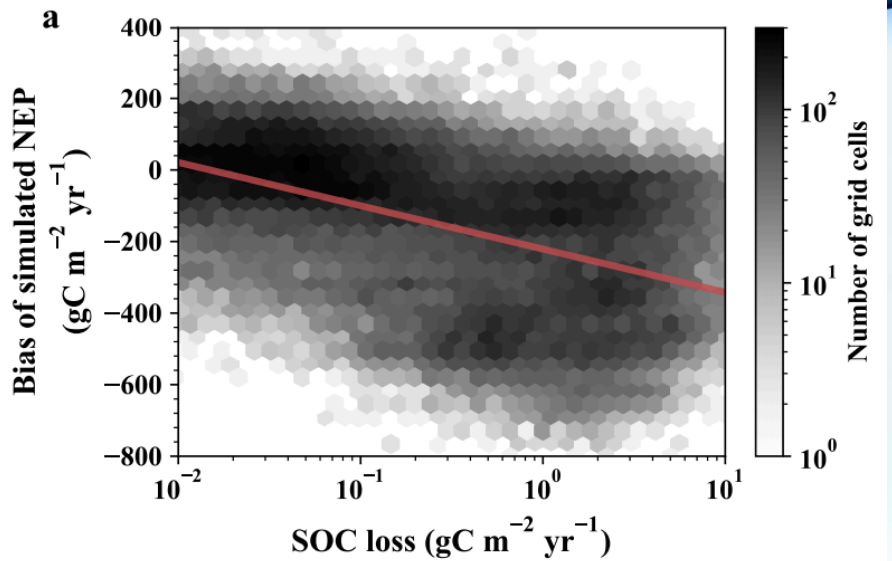
Progress - MOSART

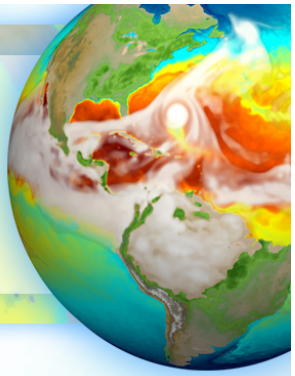
Hydrology and plant hydraulics
Water cycle
Cryosphere

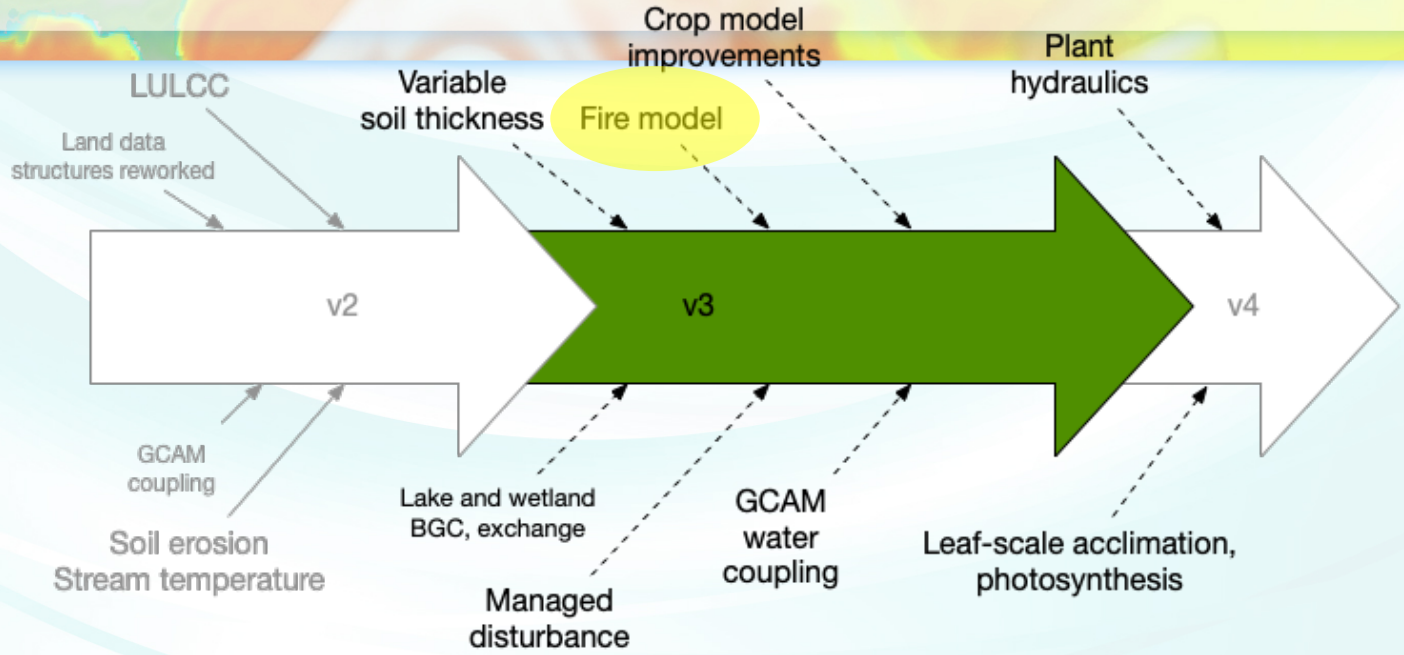
- MOSART-carbon, MOSART-lake, MOSART-wm etc. progressing on multiple fronts
- Papers on erosion, sediment transport, links with heterotrophic respiration in model



Tan et al. 2020 *Global Change Biology*

Land-Energy NGD overview





High-res NA GPU

FATES

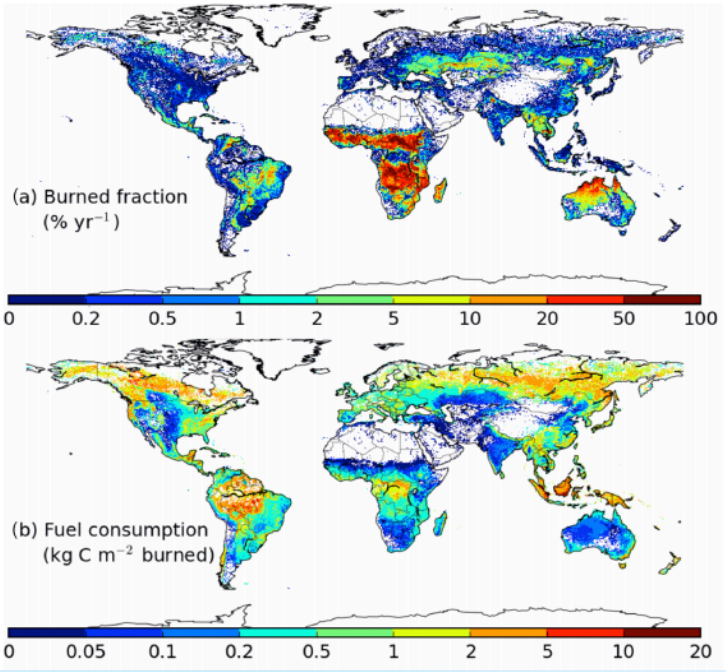
External model interface

Improving and simplifying the ELM fire model

Disturbances
Water cycle
Biogeochemistry

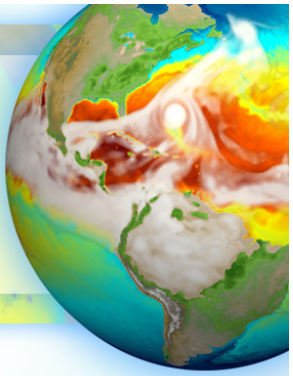
- Improve realism, and simplify structure, of the fire model
- First manuscript submitted (fire emission effects)
- Second phase (improving the fire model with GFED observations, ML fire model) is underway

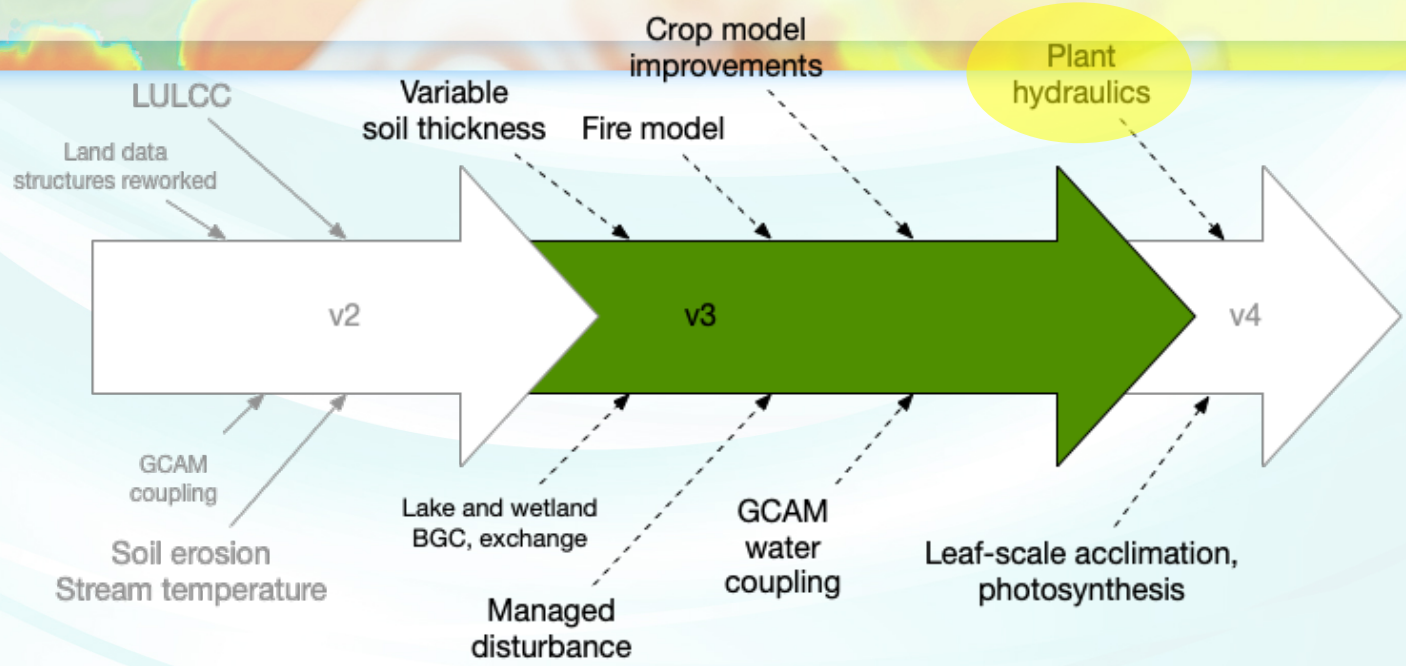
See Qing Zhu's talk on Thursday (D4S2 – BR#2)



van der Werf (2016)

Land-Energy NGD overview





E3SM Energy Exascale Earth System Model

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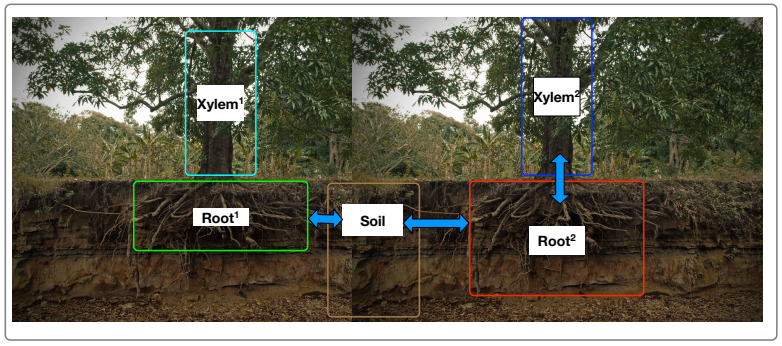
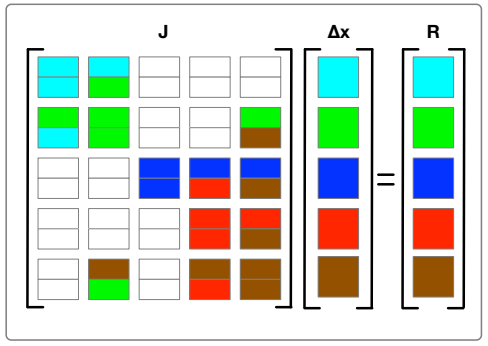
Development of a tree-level hydrodynamic model for ELM

Hydrology and plant hydraulics
Water cycle
Cryosphere

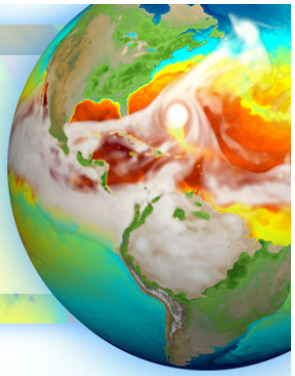
- Increasing vegetation mortality due to drought and temperature
- ELM-v1.0 excludes transport of water through vegetation structure and excludes competition for water
- Developed a tree-level hydrodynamic model that exploits PETSc's *DMComposite* to flexibly solve tightly coupled multi-physics problems

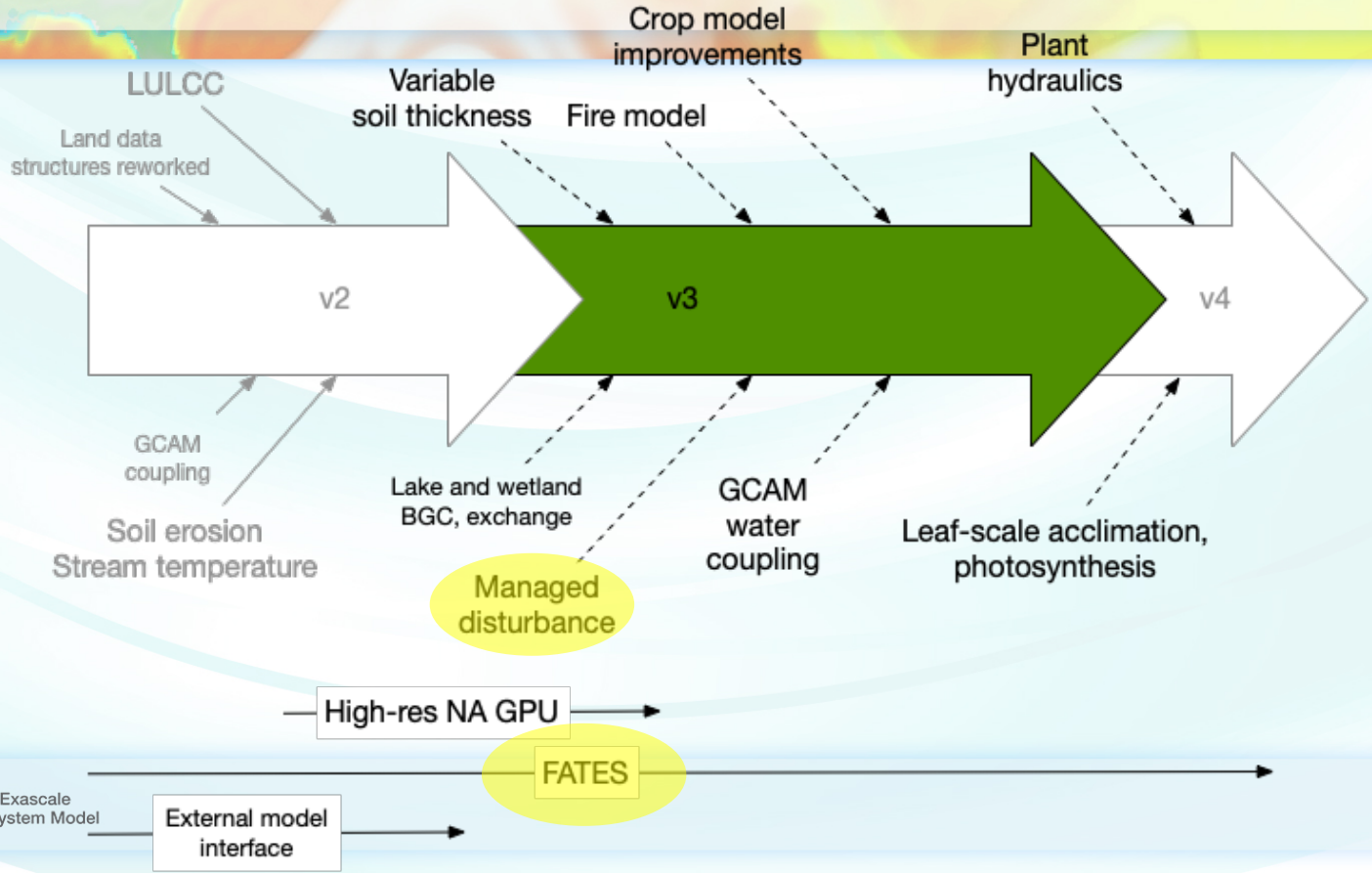




See Gautam Bisht's talk on Wednesday (D3S1 SciDAC #2)

Land-Energy NGD overview





E3SM Energy Exascale Earth System Model

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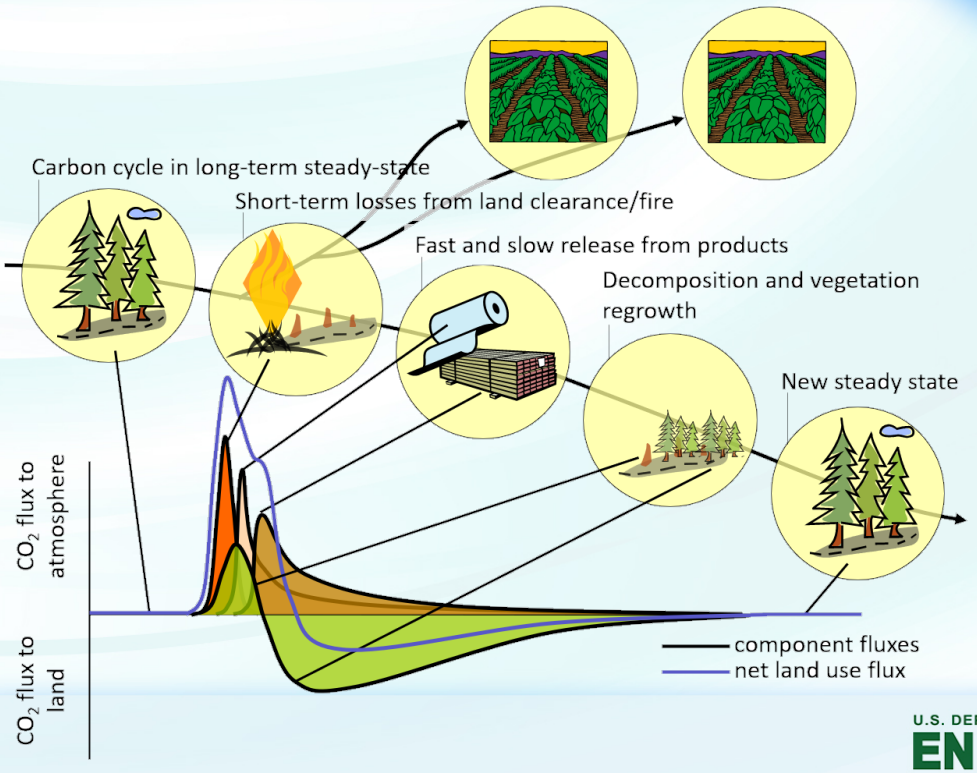
Managed disturbances

Disturbances
Water cycle
Biogeochemistry

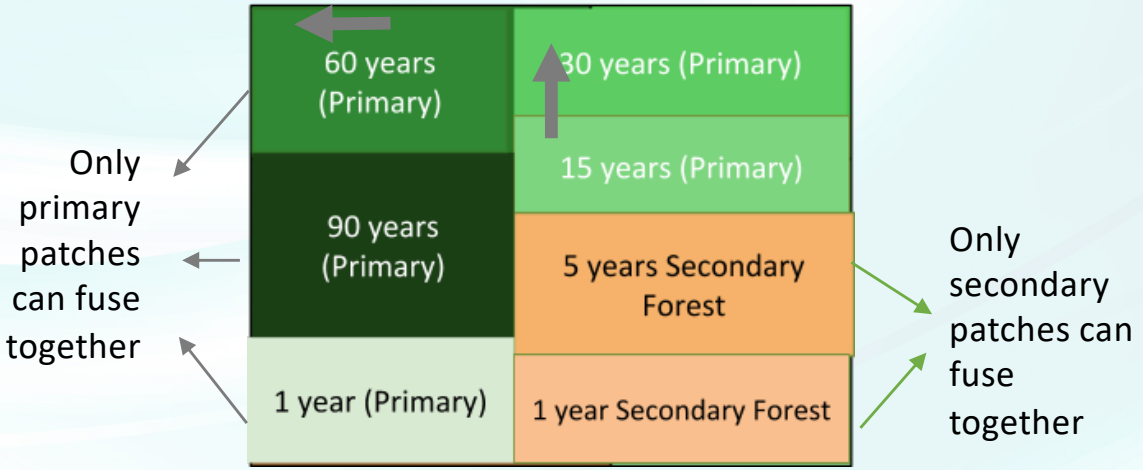
- ORNL coordinating with ANL on the use of LUH2 classes at the landunit level, including crop classes



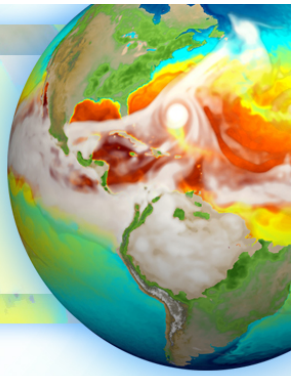
First LULCC capabilities in ELM-FATES

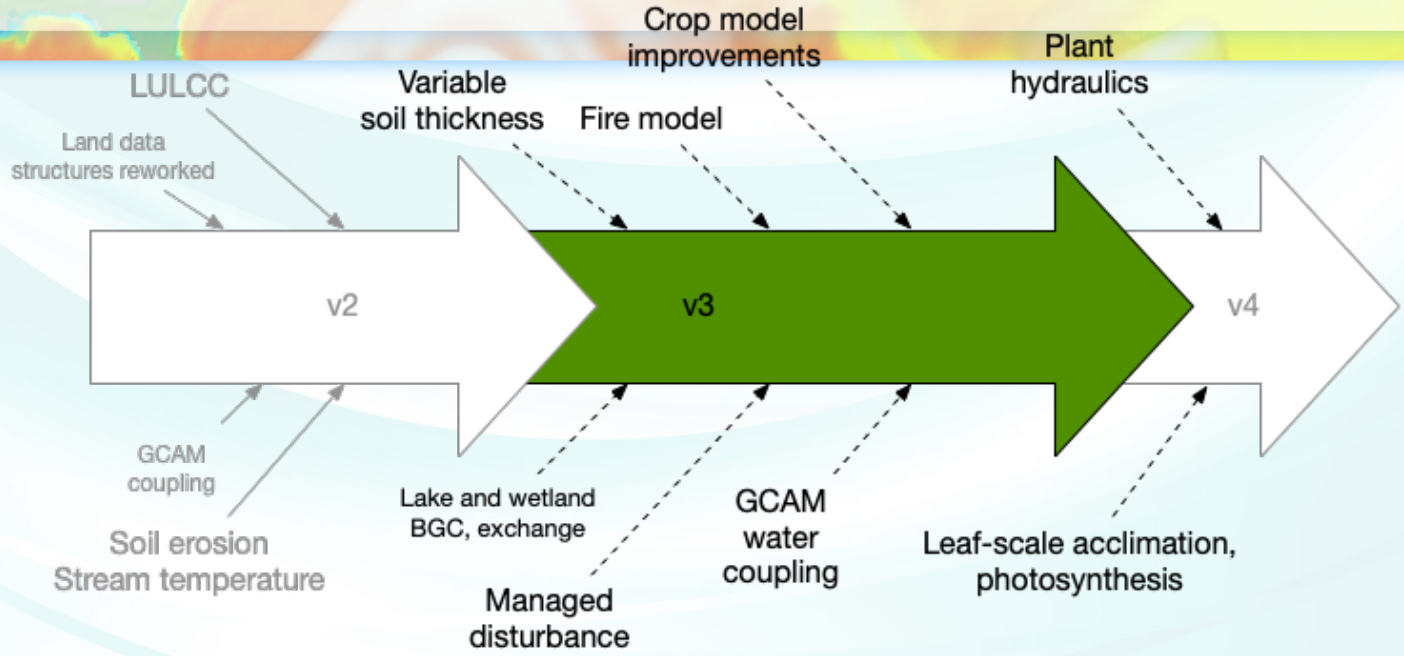
Vegetation dynamics
Biogeochemistry

- Working on getting harvest into FATES; one benchmark run completed and a global one in progress
- Testing global run on Cori: CN-Harvest works the same as before (FATES not active, just ran for a couple of years)
  - Currently regrowing forest for testing FATES harvest



Land-Energy NGD overview





High-res NA GPU

FATES

External model interface

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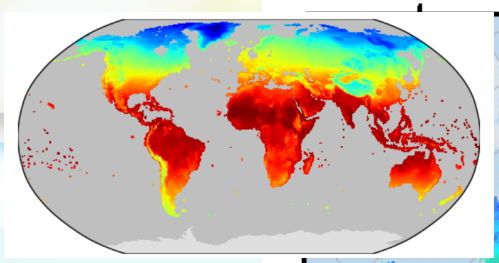
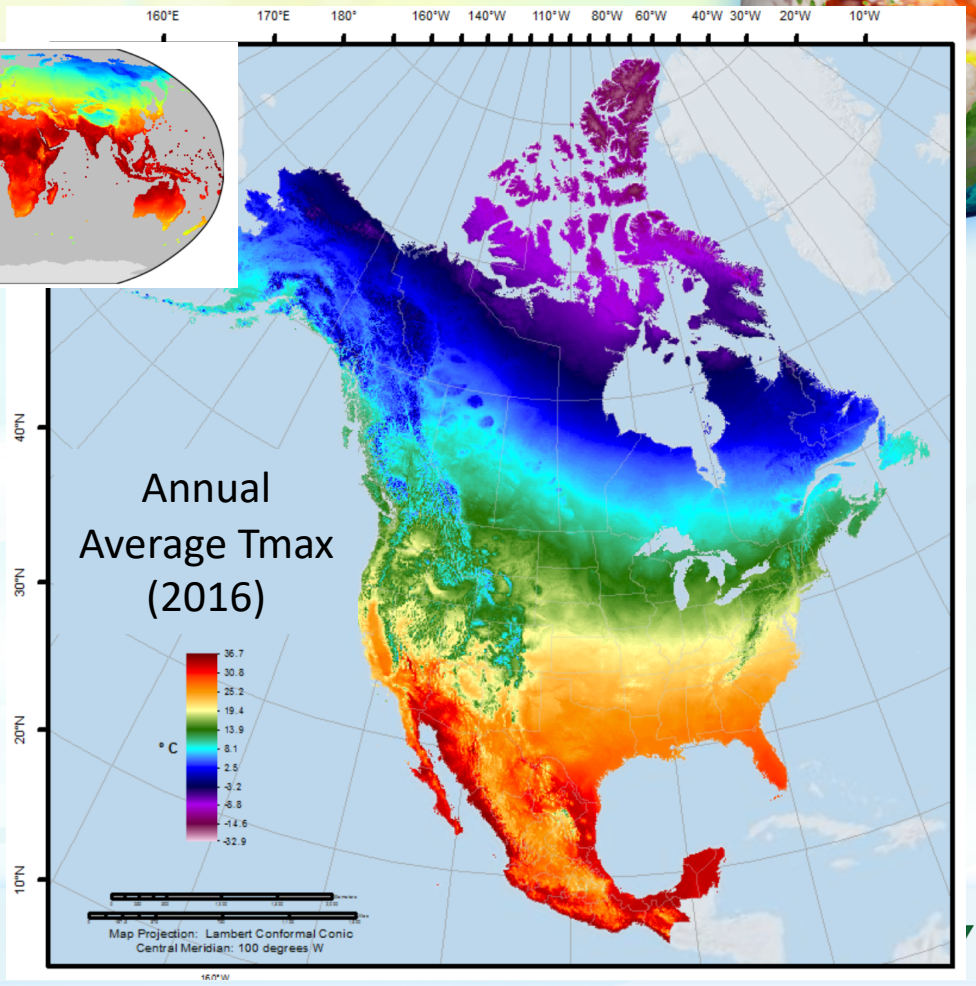
Target: 1 km^2 grid resolution over N. America

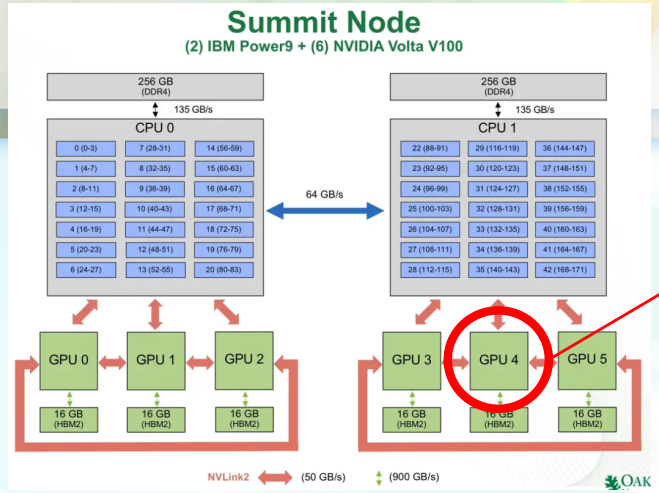


- Massively parallel ELM runs on Summit
- Refactoring, GPU performance optimization

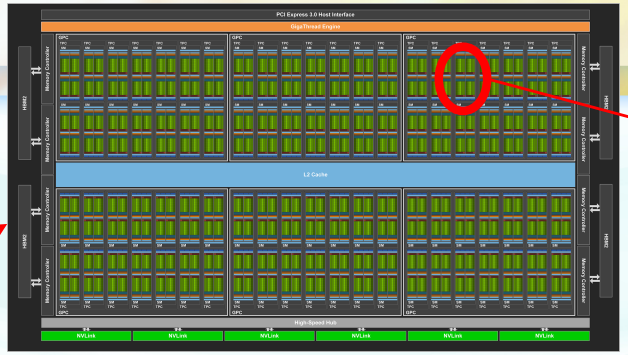


See Dali Wang's poster on Tuesday (PS1)

Computational strategy: OpenACC on Summit



Each Summit node has 6 NVIDIA Volta V100 GPUs. We plan to have 1 ELM MPI task per GPU, so 6 MPI tasks per node



Each GPU has 80+ Streaming Multiprocessors (SMs) and 16 GB of shared memory (HBM2)

Each SM has 32 double precision cores, which can be "over-subscribed" with threads to an extent that depends in part on availability of register space and heap space.

See Dali Wang's poster on Tuesday (PS1)

Questions?